

Diabetes and Impaired Fasting Glycemia in a Rural Population of Bangladesh

M. ABU SAYEED, MD, PHD¹
HAJERA MAHTAB, FCPS, FRCP¹
PARVIN AKTER KHANAM, MSc¹
ZAFAR ABDUL LATIF, FCPS¹

S. M. KERAMAT ALI, DPH, PHD²
AKHTER BANU, MSc, PHD²
BO AHREN, MD, PHD³
A.K. AZAD KHAN, FCPS, PHD¹

OBJECTIVE — To determine the prevalence of type 2 diabetes and impaired fasting glycemia (IFG) in a rural population of Bangladesh.

RESEARCH DESIGN AND METHODS — A cluster sampling of 4,923 subjects ≥ 20 years old in a rural community were investigated. Fasting plasma glucose, blood pressure, height, weight, and girth of waist and hip were measured. BMI and waist-to-hip ratio (WHR) were calculated. Total cholesterol, triglycerides, and HDL cholesterol were also estimated. We used the 1997 American Diabetes Association diagnostic criteria.

RESULTS — The crude prevalence of type 2 diabetes was 4.3% and IFG was 12.4%. The age-standardized prevalence of type 2 diabetes (95% CI) was 3.8% (3.12–4.49) and IFG was 13.0% (11.76–14.16). The subjects with higher family income had significantly higher prevalence of type 2 diabetes (5.9 vs. 3.5%, $P < 0.001$) and IFG (15.6 vs. 10.8%, $P < 0.001$) than those with lower income. Employing logistic regression in different models, we found that wealthy class, family history of diabetes, reduced physical exercise, and increased age, BMI, and WHR were the important predictors of diabetes. Total cholesterol, triglycerides, and HDL cholesterol showed no association with diabetes and IFG.

CONCLUSIONS — The prevalence of diabetes and IFG in the rural population was found to be on the increase compared with the previous reports of Bangladesh and other Asian studies. Older age, higher obesity, higher income, family history of diabetes, and reduced physical activity were proved significant risk factors for diabetes and IFG, whereas plasma lipids showed no association with diabetes and IFG. Further study may address whether diabetes is causally associated with insulin deficiency or insulin resistance.

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Type 2 diabetes appears to be a global health problem (1). Recent epidemiological reports indicated an increased prevalence of diabetes in Turkey (7.2%), India (8.2%), Pakistan (11.1%), and Hawaii (20.4%) (2–5). It is estimated that the developing countries will bear the brunt of diabetes epidemics in the 21st century (6). Some population-based studies conducted in Bangladesh at differ-

ent time points have revealed an increasing trend of diabetes prevalence ranging from 1.5 to 3.8% in the rural communities (7–11). It was also reported that Bangladeshis are more susceptible to develop diabetes, hyperinsulinemia, and coronary heart disease (CHD) compared with other South Asian migrants (Indians, Pakistani) settled in the U.K. (12). The risk factors related to these disorders were more prev-

alent in Bangladeshis than in the native population (13,14). Thus, Bangladeshis among the entire South Asian immigrant population had the highest mortality and attack rate from CHD (15). Also, in Bangladesh these diseases are emerging as major health problems, and the government has given them high research priority (16). It may be mentioned that a vast majority (77.6%) of the national population lives in rural areas (17). Only two studies were conducted in rural areas, but these studies contained small samples (9,11). This study was undertaken to estimate the prevalence of diabetes and IFG in a relatively larger sample with more risk variables. It may be noted that this study estimated the prevalence and risk factors of diabetes and IFG in a rural population at the beginning of the new millennium.

RESEARCH DESIGN AND METHODS

Geographical area and population

We conducted this study from September 1999 through March 2000. We purposively selected a rural community consisting of 19 villages under Mymensing district. The selected area is situated 250 km off Dhaka City. The sociodemographic characteristics of rural life defined for this study were the livelihood primarily related to agriculture or agrarian activities. The villages are linked by road in the dry seasons, but during monsoons the transport is mostly riverboat to and from district town. A population census was carried out before a diabetic survey. A survey questionnaire was designed and finalized after field trial. The variables included were age, sex, education, occupation, annual family income, family size, religion, and housing condition. All of the census data collected in the field were entered into a computer database, and the eligible subjects ≥ 20 years of age were included for screening.

Diabetes survey and data collection

All men and women ≥ 20 years of age were considered eligible except pregnant women and subjects on medication. The

From the ¹Department of Epidemiology and Biostatistics, Research Division, BIRDEM, Dhaka, Bangladesh; the ²Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh; and ³University of Lundh, Lundh, Sweden.

Address correspondence and reprint requests to Dr. M.A. Sayeed, Research Division, BIRDEM, 122 Kazi Nazrul Islam Avenue, Dhaka, Bangladesh. E-mail: sayeedma@dab-bd.org.

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Abbreviations: AFG, abnormal fasting glycemia; CHD, coronary heart disease; FPG, fasting plasma glucose; IFG, impaired fasting glycemia; NFG, normal fasting glucose; TG, triglycerides; WHO, World Health Organization; WHR, waist-to-hip ratio.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

eligible participants were informed about the objectives of the study. They were also informed about the site and procedural details of the investigation. After providing informed consent, each interested individual was requested to attend a specific nearby site after fasting for at least 12 h. Each participant was interviewed for the status of physical activities, family history of diabetes, hypertension, and CHD. All types of physical activities (plowing, digging, gardening, harvesting, boat-rowing, crop-carrying, manual irrigation, etc.) was graded according to the intensity and duration of work (heavy, moderate, mild, and sedentary, based on an equivalent walk of >90 min, 60–90 min, 30–59 min, and <30 min/24 h, respectively). The other investigations included anthropometry, blood pressure, and fasting plasma glucose (FPG). Measurements of height, weight, and waist and hip girth were taken with light clothes without shoes. The weighing tools were calibrated daily by known standard weight. For height, the subject stood in erect posture vertically touching the occiput, back, hip, and heels on the wall while gazing horizontally in front and keeping the tragus and lateral orbital margin in the same horizontal plane. Waist girth was measured by placing a plastic tape horizontally midway between 12th rib and iliac crest on the mid-axillary line. Similarly, hip was measured by taking the extreme end posteriorly and the symphysis pubis anteriorly. For blood pressure measurement, ensuring 10 min of rest and using standard cuffs for adults fitted with mercury sphygmomanometer minimized variation in measurement.

Taking an aseptic precaution, 5 ml of venous blood was taken for fasting plasma glucose, total cholesterol, HDL cholesterol, and triglycerides (TG). We estimated plasma glucose by the glucose oxidase (enzymatic oxidation) method (GOD/PAP Kit; Randox, Antrim, U.K.) using the auto-analyzer Screen Master-3000 (B.S. Biochemical Analyzer, Arezzo, Italy). After estimation of FPG, the participants were classified into normal and abnormal fasting glucose (NFG and AFG), based on above and below the cut point 6.1 mmol/l. AFG encompasses impaired fasting glucose (IFG) (FPG 6.1–6.9) and type 2 diabetes (≥ 7.0). All participants from the AFG group and an equal number from the NFG or control group (randomized sample) were investigated for lipid

Table 1—Prevalence (%) of IFG and type 2 diabetes according to sex, social class, physical activity, and family history of diabetes and hypertension

Variables	n	IFG (%)	χ^2	P	Diabetes (%)	χ^2	P
Sex							
Men	2,321	12.7			5.2		
Women	2,602	12.1	0.38	0.537	3.4	8.14	0.005
All	4,923	12.4			4.3		
Social class*							
Poor	3,162	10.8			3.5		
Rich	1,556	15.6	21.81	<0.001	5.9	13.60	<0.001
Family history diabetes							
No	4,581	12.1			3.9		
Yes	158	19.0	6.61	0.01	14.1	36.51	<0.001
Family history hypertension							
No	4,353	12.0			4.2		
Yes	386	16.1	5.30	0.021	5.5	1.48	0.211
Physical activity†							
≥ 90 min	2,679	11.5			3.5		
60–89 min	1,027	14.1	5.10	0.165	3.6	16.89	0.001
30–59 min	916	13.1			6.1		
<30 min	160	12.1			8.4		

χ^2 for men vs. women, poor vs. rich, etc. *Categorized based on tertile of annual expenditure: top tertile (rich) and lower tertiles (poor). †Equivalent to x min of walking per day.

profiles. For screening of IFG and type 2 diabetes, we used diagnostic criteria of American Diabetes Association (18).

Statistical methods

The prevalence rates of type 2 diabetes and IFG were determined by simple percentages. Age-specific and age-standardized (30–70 years) prevalence rates were estimated on the basis of 1991 census data adjusted in 2000 (17,19). All associations were tested by χ^2 and correlation coefficient (*r*). The odds ratio (OR) with 95% confidence interval (CI) for risk factors was calculated assuming the least prevalence of diabetes as a reference in the lowest quintile of age, BMI, and waist-to-hip ratio (WHR). Binary logistic regression was used to quantify the individual risk predicting diabetes in various models with different combination of independent risk factors. The risk factors quantified were sex (men/women) and economic status (poor/rich). In addition, we tested BMI, WHR, TG, total cholesterol, and HDL cholesterol in quintiles in different models. All statistical tests were considered significant at a level $\leq 5\%$. SPSS version 10.05 was used.

RESULTS— The population census included 16,818 individuals (8,687 men,

8,131 women) of all age-groups from 3,632 households. Each household consists of about five family members. The family size was five at the 50th percentile and seven at the 80th percentile. Most of the population was Muslim (99.4%) and the rest was Hindu. About 75% of the adult population (≥ 20 years) was illiterate (unable to write his/her address), and only 1.8% was found to have successfully obtained an academic degree. Occupationally, 49.6% were housewives, 24.4% farmers, 6.8% day laborers, 4% businessmen, 3.5% students, 1.7% servicemen, and 4.7% had mixed occupations.

The mean annual family income was \$838 U.S. (95% CI 821–856). For comparison, we classified the top tertile of annual income as the high-income group ($\geq \$848$) and the lower two tertiles as the low-income group ($< \$848$). In regard to living status, 73% of the roofs of living rooms were made of corrugated tins and 26% were thatch. Only 12.6% of the family had access to sanitary latrine, and the rest had either none or open type (exposed to the environment). Family history revealed that first-degree relatives had hypertension in 8.2%, diabetes in 3.6%, stroke in 2.5%, and CHD in 0.6% of the population.

Of the 5,713 eligible (≥ 20 years old)

Table 2—Age-specific and age-standardized prevalence (with 95% CI) of IFG and type 2 diabetes in 2,321 men and 2,602 women

	Age-specific (years) prevalence (%) (95% CI)					Age-standardized prevalence (%) (95% CI)
	20–29	30–39	40–49	50–59	≥60	30–70
Type 2 diabetes						
Men	3.4 (2.02–4.83)	3.4 (1.96–4.92)	4.4 (2.58–6.30)	7.3 (4.08–10.61)	6.1 (3.55–8.59)	4.6 (3.54–5.69)
Women	1.9 (0.98–2.72)	2.3 (1.19–3.43)	3.0 (1.31–4.61)	3.8 (1.51–6.18)	7.5 (4.51–10.56)	3.1 (2.18–3.92)
All	2.5 (1.71–3.25)	2.8 (1.90–3.70)	3.7 (2.47–4.97)	5.5 (3.51–7.45)	6.7* (4.74–8.59)	3.8 (3.12–4.49)
IFG						
Men	10.4 (8.07–12.80)	13.3 (10.50–16.01)	11.8 (8.93–14.75)	11.4 (7.44–15.41)	14.2 (10.49–17.84)	12.6 (10.87–14.27)
Women	9.3 (7.38–11.13)	11.5 (9.16–13.92)	11.4 (8.27–14.45)	17.7 (13.05–22.33)	15.8 (11.57–19.93)	13.4 (11.66–15.08)
All	9.7 (8.21–11.14)	12.2 (10.42–14.00)	11.5 (9.40–13.60)	14.5 (11.43–17.53)	14.7* (11.99–17.46)	13.0 (11.76–14.16)

Age adjustment was based on adjusted census of 1996. * χ^2 trend = $P < 0.001$.

subjects for screening, 4,923 (2,321 men, 2,602 women) volunteered. The response rate was 86.2%.

The overall prevalence of diabetes was 4.3% and IFG was 12.4% (Table 1). The male participants had a significantly higher prevalence of diabetes than their female counterparts (5.2 vs. 3.2%; χ^2 8.14, $P = 0.005$), whereas the prevalence of IFG did not differ between men and women (12.7 vs. 12.1%; χ^2 0.38, $P = 0.38$). The subjects with high annual income had significantly higher prevalence of diabetes and IFG (for both, $P < 0.001$). The prevalence rates of diabetes (χ^2 36.5, $P < 0.001$) and IFG (χ^2 6.6, $P = 0.01$) were significantly higher among those with family history of diabetes than those without. Family history of hypertension also showed higher prevalence of diabetes and IFG though it was significant only for IFG. The prevalence of diabetes was consistently and significantly higher with less physical activity ($P < 0.001$) (Table 1).

The age-specific prevalence of both type 2 diabetes and IFG showed an increasing trend with increasing age (Table 2). The trends were significant for both type 2 diabetes ($P < 0.001$) and IFG ($P < 0.001$). The age-standardized (30–70 years) prevalence of type 2 diabetes (95% CI) was 3.8% (3.12–4.49) and for IFG was 13.0% (11.76–14.16). Age-standardized prevalence did not differ significantly between men and women for both type 2 diabetes (4.6 vs. 3.1%) and IFG (12.6 vs. 13.4%).

The characteristics were compared between subjects with NFG and AFG (FPG: ≥ 6.1 vs. < 6.1) (Table 3). The subjects with AFG were older with significantly higher BMI, WHR, blood pressure,

and plasma glucose. Interestingly, total cholesterol was significantly higher in the normoglycemic subjects and HDL cholesterol was significantly higher in the hyperglycemic group; TG did not show any significant difference. The comparisons of characteristics between NFG and IFG and between NFG and type 2 diabetes separately yielded similar results (data not shown). In partial correlation, controlling for age and sex, FPG showed significant positive association with BMI, WHR, systolic blood pressure, and diastolic blood pressure (for all, $P < 0.001$), whereas no significant correlation was found with total cholesterol, TG, and HDL cholesterol.

We used logistic regression to quantify the individual effect of predictor variables (sex, family income, BMI, WHR,

and lipids), with diabetes as a dependent variable in different models (Table 3). In model 1, the predictors sex, social class, family history of diabetes, and physical activity were entered. The males showed excess risk (OR 1.84, 95% CI 1.34–2.53). This excess risk, though, was no longer significant when age and WHR were entered in the model (models 2 and 4). In contrast, the rich class was proved to be an important predictor because other variables could not reduce its effect. A similar important risk was positive family history of diabetes. Less physical activity (equivalent to < 30 min of walking per day) was equally proven significant, although its effect could be reduced only by age and not by BMI and WHR.

In the subsequent models (models

Table 3—Characteristics compared between NFG and AFG (fasting blood glucose < 6.0 and ≥ 6.0 mmol/l)

	NFG (n = 4,118)		AFG (n = 759)		P (NFG vs. AFG)
	Mean	SD	Mean	SD	
Age (years)	37.72	15.00	41.49	16.19	0.000
Height (cm)	156.48	8.61	156.56	8.80	0.833
Weight (kg)	43.94	7.36	45.95	9.28	0.000
Waist (cm)	67.15	7.14	69.83	9.03	0.000
Hip (cm)	78.13	5.48	79.77	6.25	0.000
BMI (kg/m ²)	17.91	2.41	18.709	3.186	0.000
WHR	0.859	0.064	0.874	0.071	0.000
SBP (mmHg)	119.22	20.33	123.83	23.13	0.000
DBP (mmHg)	76.50	10.31	77.90	10.88	0.001
FPG (mmol/l)	3.97	0.58	6.02	1.84	0.000
TG* (mg/dl)	166.59	94.99	161.46	84.05	0.281
Tot cholesterol* (mg/dl)	162.51	65.11	156.36	52.85	0.047
HDL cholesterol* (mg/dl)	39.47	13.80	41.14	14.40	0.031

*Randomized sample (NFG = 1,060; AFG = 499).

Table 4—Binary logistic regression risk factors selected stepwise in different models taking type 2 diabetes as a dependent variable

Risk factors	Model 1		Model 2		Model 3		Model 4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Sex: F 1, M 2	1.84	1.34–2.53	1.38	0.99–1.92	1.48	1.06–2.06	1.32	0.94–1.85
Social class: Poor 1, rich 2	1.50	1.10–2.10	1.74	1.28–2.36	1.54	1.13–2.11	1.49	1.09–2.04
Family history of diabetes								
No 1, yes 2	2.93	1.72–4.98	3.10	1.81–5.29	2.62	1.52–4.54	2.78	1.61–4.79
Physical activity*								
≥90 min	1	—						
60–89 min	1.09	0.72–1.66						
30–59 min	1.94	1.33–2.82						
<30 min	2.73	1.44–5.17						
Age								
Quintile 1†			1.0	—	1.0	—	1.0	—
Quintile 2			1.16	0.71–1.89	1.12	0.68–1.82	1.05	0.64–1.73
Quintile 3			1.33	0.80–2.20	1.29	0.77–2.14	1.14	0.68–1.90
Quintile 4			2.75	1.77–4.26	2.87	1.84–4.49	2.39	1.53–3.74
BMI								
Quintile 1†					1.0	—		
Quintile 2					0.85	0.53–1.39		
Quintile 3					1.20	0.76–1.90		
Quintile 4					2.15	1.41–3.27		
WHR								
Quintile 1†							1.0	—
Quintile 2							0.90	0.55–1.47
Quintile 3							1.11	0.69–1.78
Quintile 4							2.01	1.30–3.12

*Physical activity equivalent to *x* minutes of walking per day; excluded from model, 2–4; †risk factors in quintile; quintile 1 is taken as reference category. BMI was excluded from model 4.

2–4), the quintiles of age, BMI, and WHR were entered. It was found that the highest quintiles of age, BMI, and WHR were proven significant predictors of diabetes.

CONCLUSIONS

This study addressed the prevalence of diabetes and IFG in a rural population in Bangladesh. The response rate (86.2%) is satisfactory, which indicates the active cooperation of the rural participants.

The prevalence of diabetes (3.7%) observed in this study is almost comparable to or higher than in the previous studies (9–10). The observed rate of diabetes is lower than that of the rural population of Turkey (7.2%), Pakistan (11.1%), and Hawaii (20.4%) (2,4,5). It is higher, though, than in China (2.5%), Mongolia (2.9%), and India (2.4%) (20,21,26). It appears that the diabetes prevalence in rural Bangladesh is moderately increased. Although there is no recent data on rural India for comparison, the recent report on urban Indians shows much higher prevalence (8.2%) (3). Thus, the prevalence varied widely among the Asians. It may be

due to ethnic susceptibility, urbanized lifestyle, or both (1,6,12). Most of the studies observed that, regardless of ethnicity, this metabolic disease increased with economic development related to affluent lifestyle, with excess calorie intake and less physical activities resulting from the embrace of a more modernized lifestyle in favor of a traditional lifestyle (22–25). The preponderance of diabetes in the rural rich indicates the same.

In rural Bangladesh, road communication, electrification, and mechanized cultivation in recent years has minimized physical activity. Average calorie intake is also at its highest level (17). As such, per capita food consumption has increased from 173.6 kg in 1994–1995 to 198.1 kg in 1998–1999. The total measure of roads and highways has also increased in the same period from 14,949 to 21,714 km, and total commercial energy consumption (petroleum product, natural gas, coal, and electricity) has increased from 5,618,000 tons (oil equivalent) to 5,892,000 tons (17). These developmental changes have influenced the lifestyle of

rural people. However, as Bangladesh is the least developing country—its rural economy is not better than that of China (17) or Mongolia. Therefore, higher prevalence in the study population indicates the involvement of not only environmental factors, but also of some other unexplained predictors (e.g., genetic predisposition) (12–14).

Higher prevalence among the male participants was not a consistent finding. Both men and women were shown to have equal risk for diabetes in a multivariate model. Gender difference was not significant in India (3), but higher prevalence in women was found in Turkey (2) and Pakistan (4).

The most consistent risk factor was the positive family history of diabetes. For type 2 diabetes, this is not an unusual finding (3,26,27). Another risk factor evident in the study was the high social class. This is a very common finding in almost all Asian studies (3,11,22,25–27). Less physical activities equivalent to <30 min of walking per day showed a 2.2-fold risk of diabetes compared with the equiv-

alent of walking >60 min/day. Here, only age confounded the effect of exercise. It is possible that the aging process contributed much more to the development of diabetes than did reduced physical activity.

It is of interest to note that both general obesity (high BMI) and central obesity (high WHR) were found to have excess risk, but only with highest quintiles in logistic models. Moreover, though the means (SD) of BMI and WHR were significantly higher ($P = 0.000$ for both; Table 2) in those with AFG, both values do not appear to be abnormal compared with other Asian studies (3,28). This suggests that the obesity-related risk in our study population is not similar to that found in Asian and Western populations; or, it could suggest that the study population might have lower thresholds for BMI and WHR.

Another striking observation was that the lipids (total cholesterol, TG, HDL cholesterol) showed association with neither IFG nor diabetes. Thus, the possibility of insulin resistance encompassing dyslipidemia in the study subjects may be questioned. Further study in this regard may explain whether insulin deficiency or resistance is the cause of hyperglycemia; if it is insulin resistance, then additional study will be needed to determine whether it encompasses dyslipidemia.

We conclude that the prevalence of diabetes and IFG showed a moderate increase in the rural population of Bangladesh. Both men and women had equal risk of diabetes. Higher annual income, positive family history of diabetes, advancing age, and reduced physical activity were independent risk factors. Though plasma lipids were not associated with fasting hyperglycemia, obesity of some degree was related to diabetes. Further study may be undertaken to explain whether diabetes and IFG are causally related to insulin deficiency or insulin resistance.

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